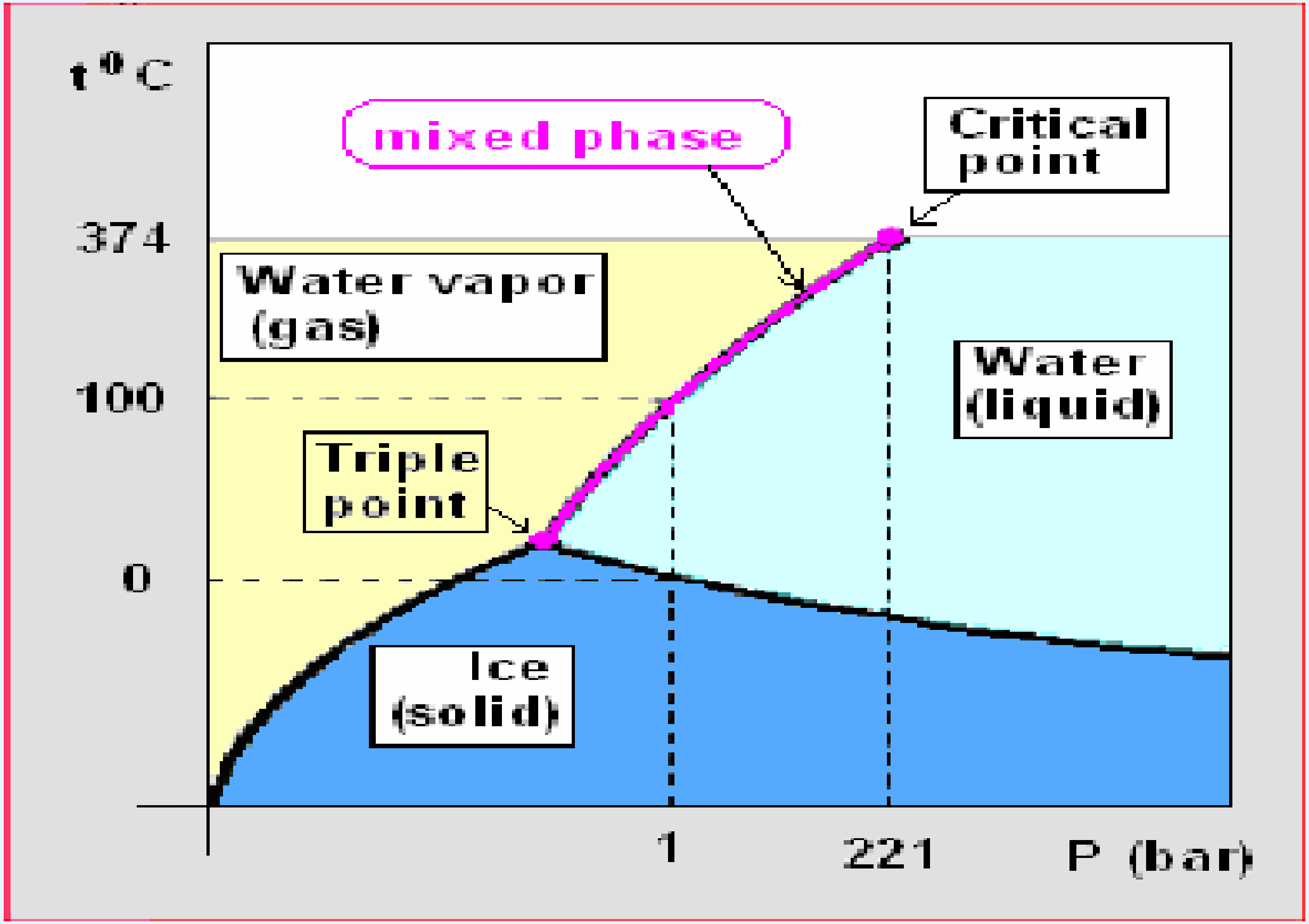
JINR 1956-2006 DUBNA

JOINT INSTITUTE FOR NUCLEAR RESEARCH

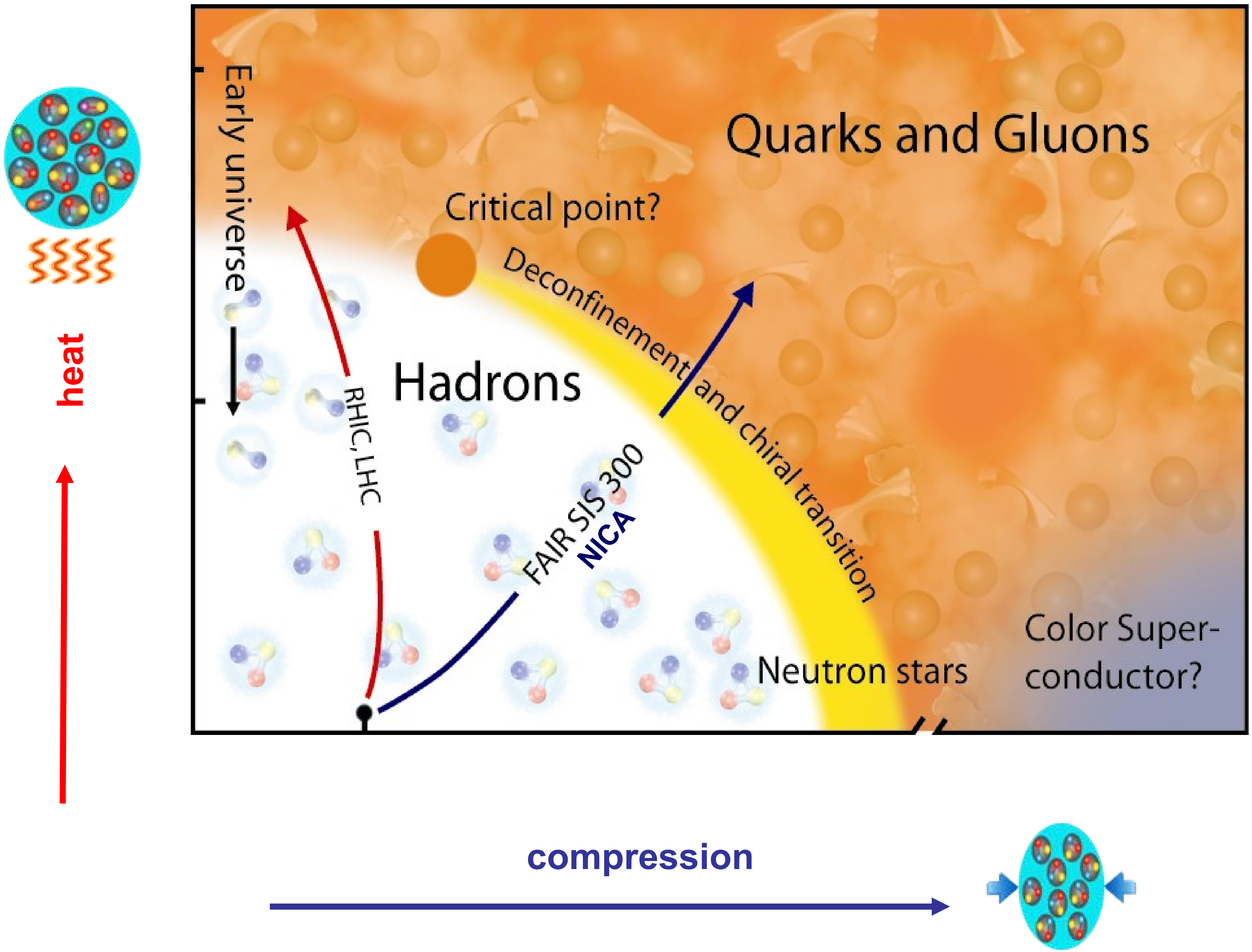
Status of the project NICA/MPD at JINR

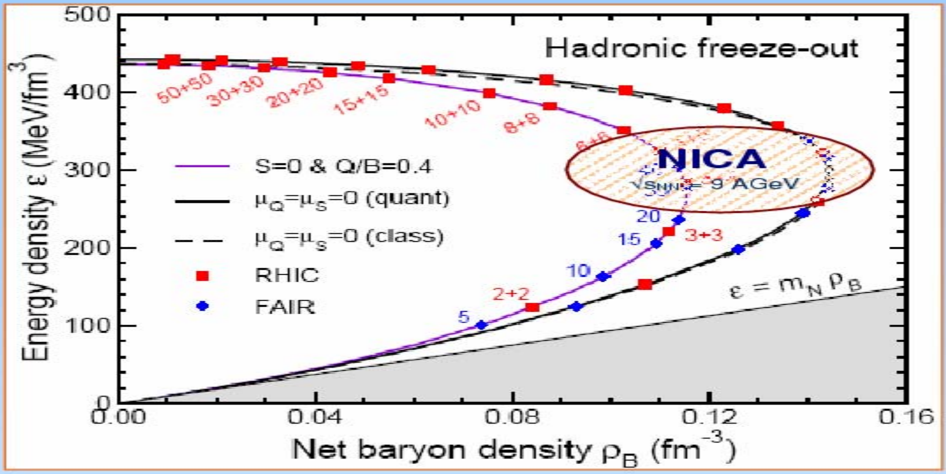
A.N.Sissakian, A.S.Sorin

Scientific Workshop dedicated to the centenary of V.I.Veksler's birth
and the 50th anniversary of launching the Synchrophasotron
JINR, Dubna, October 10 - 12, 2007

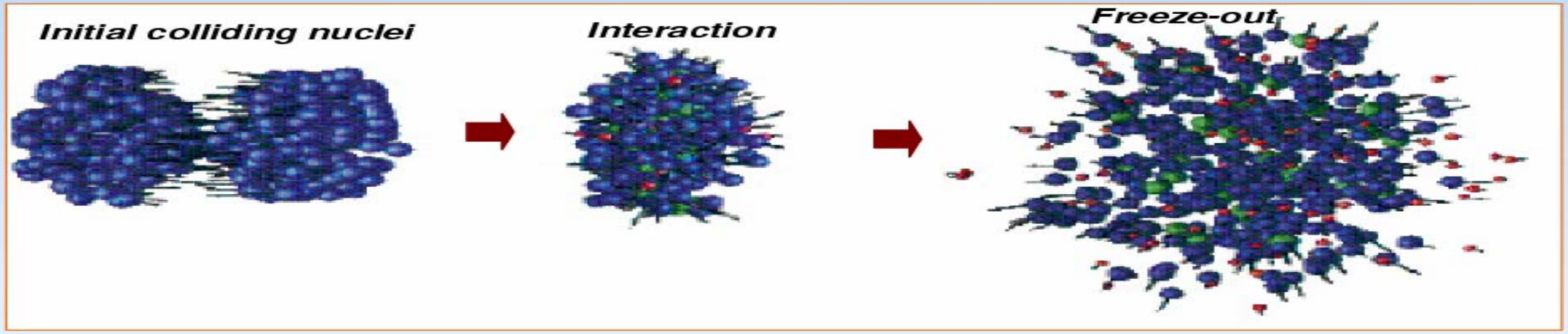

t °C
mixed phase
Critical point
374
Water vapor (gas)
100
Water (liquid)
Triple point
0
Ice (solid)
1
221
P (bar)

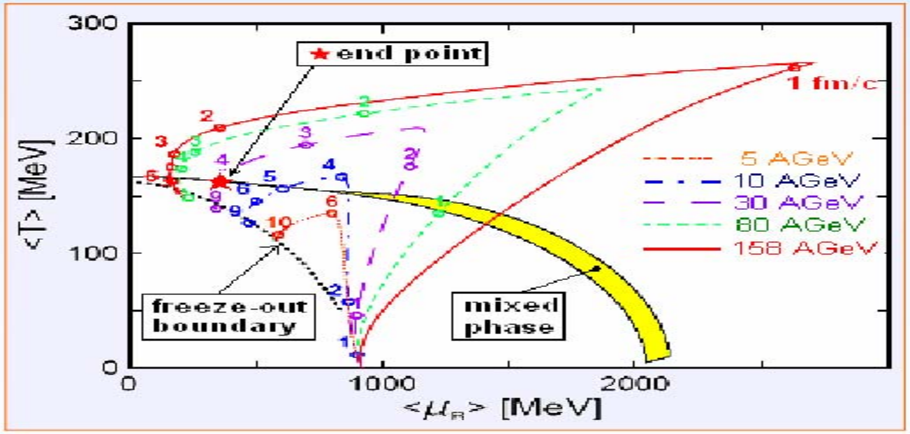

T (MeV)
250
200
150
100
50


Quarks and Gluons
Critical point?
Early universe
Deconfinement and chiral transition
Hadrons
RHIC, LHC
FAIR SIS 300
NICA
Neutron stars
Color Super-
conductor?
heat
compression

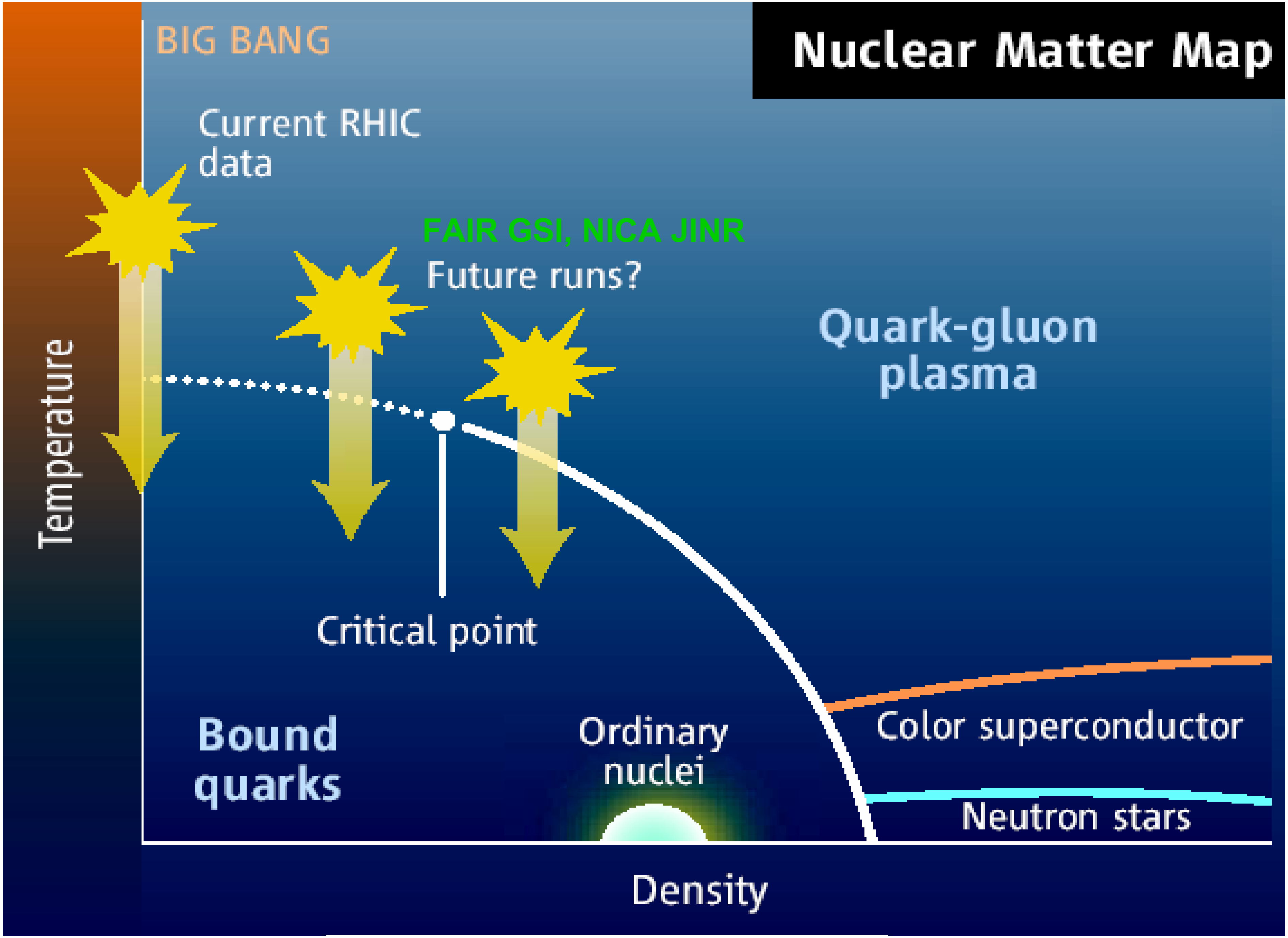


Freeze-out (cease of particle interactions in the system) estimated for different colliding energies (J.Randrup and J.Cleymans, 2006). Freeze-out baryon density is maximal at collider energy $\sqrt{s_{NN}}$= (4+4) GeV. The blue colored numbers stand for energy in the laboratory system, the red ones - in the system of centre of mass.





Phase trajectories in the phase diagram calculated within the 3-fluid hydrodynamic model for central Au+Au collisions at different energies (Yu. Ivanov V.N.Russkikh, V.D.Toneev, 2005; A.N.Sissakian, A.S.Sorin, M.K.Suleymanov, V.D.Toneev, G.M.Zinovjev, 2005, 2006). Freeze-out curve is shown by dots, the shaded region is a mixed phase for baryon and strange conserved charges. For E_{lab} = 30 AGeV ($\sqrt{s_{NN}}$ = 8 GeV) the trajectory goes near the critical end-point. Points with numbers indicate the time of the system evolution (1 fm/c ~ $3.3 \cdot 10^{-24}$ sec).



14 APRIL 2006 VOL 312 SCIENCE www.sciencemag.org

NICA goals and physics problems

Study of in-medium properties of hadrons and nuclear matter equation of state, including a search for possible signs of deconfinement and/or chiral symmetry restoration phase transitions and QCD critical endpoint in the region of $\sqrt{s}_{NN}$=4-9 GeV

by means of careful scanning in beam energy and centrality of excitation functions for

the first stage

♣ Multiplicity and global characteristics of identified hadrons including multi-strange particles
♣ Fluctuations in multiplicity and transverse momenta
♣ Directed and elliptic flows for various hadrons
♣ HBT and particle correlations

the second stage

♣ **Electromagnetic probes (photons and dileptons)**

Required parameters

The following basic initial parameters have been accepted in designing physical installation:

Kinetic energy of each colliding beam 2.5 A GeV
The setup covers solid angle close to 4π
Average luminosity of colliding beams 1×10^{27} cm-2·s-1
Total cross section of heavy ion interaction (U+U) 7 b
The mean multiplicity of charged particles in a central collision 600
Fraction of central collisions 5%
Fraction of events with strange particles 3%
Fraction of events with lepton pairs in domain of ρ meson 10^{-4}

The following interaction rate characterizes the setup capability:

- Frequency of interaction 7×10^{3} /s

Total number of interactions per year assuming the statistics is being collected for 50% of the calendar time 1×10^{11}
A number of central interactions per year 5×10^{9}
A number of central interactions with strange particles per year 3×10^{8}
A number of central interactions with lepton pairs in the domain of ρ meson per year 5×10^{5}

From these estimations it is possible to conclude that luminosity 10^{27} cm-2·s-1 may be sufficient for the decision of the above formulated physical program.

Heavy Ion Accelerators

SIS

BEVALAC
(shut down)

NUCLOTRON

Synchrophasotron
(shut down)

SPS

RHIC
AGS
(shut down)

	E (GeV)	$S^{1/2}$ (GeV)
AGS BNL Au+Au 1985 −1990	2 ÷ 11	2.3 ÷ 4.7
SPS CERN Pb+Pb 2003 2002 2000 2000 1994 − 2000	 20 30 40 80 160	 6.3 7.6 8.3 12.3 17.4
RHIC BNL Au+Au 2000 − ?	$2.1 \cdot 10^4$	200

Relativistic Heavy Ion Facilities from Synchrophasotron and AGS to NICA and FAIR

Over the last 30 years a lot of efforts have been made to provide the conditions for searching for new states of strongly interacting matter under extreme conditions.

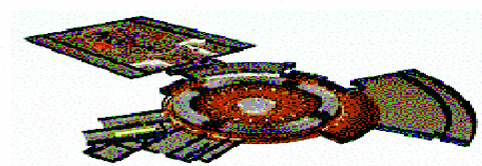
Synchrophasotron: $E_{lab} \sim 4.2$ AGeV ($\sqrt{s_{NN}} = 3$GeV)
1971 - 1999, pioneering experiments in the field of relativistic nuclear physics.

AGS: $E_{lab} \sim 11$ AGeV ($\sqrt{s_{NN}} = 5$GeV)
1986 — 1992, study of compressed baryonic matter.

SPS: $E_{lab} \sim 158$ AGeV ($\sqrt{s_{NN}} = 18$ GeV)
1986- up to now,
study of compressed baryonic matter.

RHIC: $\sqrt{s_{NN}} = 200$ GeV ($E_{lab} \sim 80000$ AGeV)
1996 - up to now.

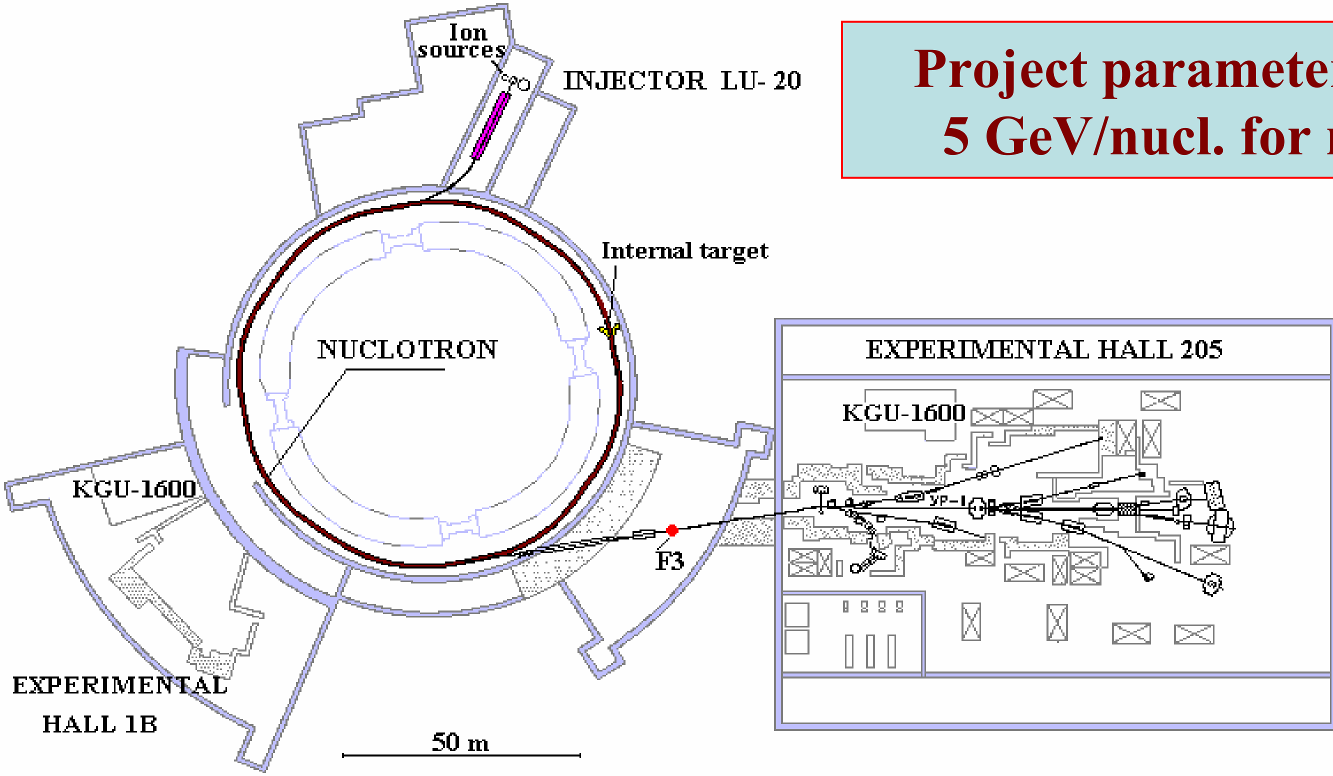
LHC: $\sqrt{s_{NN}} = 5600$ AGeV ($E_{lab} \sim 6.3 \cdot 10^7$ AGeV)
2009 - planned



SIS 300: (FAIR GSI) $E_{lab} \sim 34$ AGeV
($\sqrt{s_{NN}} = 8.5$ GeV),
full performance will be reached in 2015,
study of compressed baryonic matter.

NICA: $\sqrt{s_{NN}} = 9$ GeV ($E_{lab} \sim 40$ AGeV).
full performance will be reached in 2013,
search for the mixed phase of strongly interacting matter.

JINR NUCLOTRON



Project parameters: maximum energy 5 GeV/nucl. for nuclei with A ~ 200.

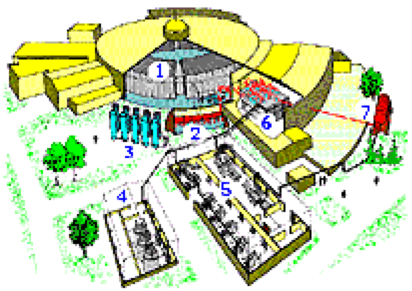
Round Table Discussion

Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron

July 7 - 9, 2005

Program

Talks



Organizing Committee

Photographs

Research Program & Expert's Report

http://theor.jinr.ru/meetings/2005/roundtable/

JINR Joint Institute for Nuclear Research

Round Table Discussion II
Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron:
Nuclotron facility development

JINR, Dubna, October 6-7, 2006

http://theor.jinr.ru/meetings/2006/roundtable/

Joint Institute for Nuclear Research

Conceptual project

Design and construction of Nuclotron-based Ion Collider fAcility (NICA) and Mixed Phase Detector (MPD)

NICA - project

Project leaders: A.Sissakian, A.Sorin

Group leaders	Group members
A.Sissakian (physics program)	A.Sorin, V.Toneev
I. Meshkov (accelerator group I)	A.Butenko, V.Kobets, V.Mikhaylov, A.Sidorin, A.V.Smirnov,
A. Kovalenko (accelerator group II)	N.Agapov, A.Alfeev, A.Butenko, E.Donets,jr, A.Eliseev, I.Issinsky, V.Karpinsky, G.Khodzhibagiyan, V.Mikhaylov, V.Monchinsky, A.A.Smirnov, A.Starikov, B.Vasilishin, V.Volkov
V. Nikitin (detector group I)	
A. Malakhov (detector group II)	S.Afanasiev, V.Golovatyuk, A.Litvinenko, P.Zarubin, L.Zolin
S. Bogomolov (ion source group)	E.Donets, A.Efremov

Dubna 2006

http://theor.jinr.ru/meetings/2006/roundtable/

VI. Recommendation on the experimental studies of the mixed phase of strongly interacting matter at the Nuclotron

The PAC notes with interest the report by A. Sorin on the plan for a future programme to study the mixed phase of QCD matter at the Nuclotron. The PAC concurs that the scientific merit of this research is high, and that a timely research programme initiated prior to the start of the FAIR programme will be competitive and attract international interest.

The PAC is concerned that carrying out this programme on the timescale indicated will require a major commitment of manpower and resources on a scale much larger than that allocated for operation and development of the Nuclotron in recent years. The PAC strongly recommends the creation of a fully developed, resource loaded project plan which shows how this programme will be carried out, how it will be financed, and the schedule for its completion. The creation of this plan will not only help to insure the success of the project, but will also help the Directorate to assess the impact of this major construction effort on the ongoing particle physics research programme in other areas.

The PAC recommends further that in the future, assuming the project to upgrade the Nuclotron moves forward, there should be an effort to convene the international scientific community which potentially may utilize this new facility to discuss ideas for experiments and detectors which ultimately may be part of the experimental programme.

The PAC invites a fully developed proposal for the experimental research programme related to this activity at its next meeting.

101st Session of the JINR Scientific Council
18-19 January 2007

The Scientific Council reiterates its previous recommendations on the central importance of the JINR basic facilities for the future development of the Institute, and notes with satisfaction the results achieved in the DRIBs and IREN projects, the ongoing modernization of the IBR-2 reactor, and the conceptual foundation being laid for a future Nuclotron-NICA project.

02-0-1065-2007/2009

Priority:	1

Status: New

Development of the JINR Basic Facility for Generation of Intense Heavy Ion and Polarized Nuclear Beams Aimed at Searching for the Mixed Phase of Nuclear Matter and Investigation of Polarization Phenomena at the Collision Energies up to $\sqrt{s_{NN}} = 9$ GeV.

Leader: A.N. Sissakian
A.S. Sorin
A.D. Kovalenko

Scientific Programme:
Investigation of the mixed phase formation problem in strongly interacting nuclear matter at extremely high nuclear densities and polarization phenomena in few-body nucleon systems. Development of theoretical models of the processes and theoretical support of the experiments. Development of the Nuclotron as the basis for study of relativistic nuclear collisions over atomic mass range A = 1-238. Preparation of the project of the nuclear collider and multipurpose particle detector at heavy ion colliding beams (NICA/MPD) and staged realization. Experiments at the Nuclotron nuclear and polarized deuteron beams.

Expected main results in 2007:

- Specification of necessary parameters of the accelerator complex and multipurpose detector for investigation of the mixed phase and other topical problems of the physics of relativistic hadrons, heavy ions and polarized particle interactions.

- Development of a highly charged state heavy ion source KRION; R&D work on the Nuclotron heavy ion pre-accelerator and partial realization of the new pumping system of the Nuclotron vacuum chamber. Commissioning of the upgraded system for the main magnetic field cycle control. Development of a beam diagnostic system at the accelerator complex. Design, construction and tests of the new model and prototype superconducting magnets for the Nuclotron development and the SIS 100 project at GSI.

- Preparation of the project of heavy ion collider NICA (Nuclotron-based Ion Collider fAcility) aimed at reaching the collision energy of $\sqrt{S_{NN}} = 4 \div 9$ GeV and averaged luminosity of $1 \cdot 10^{27}$ см$^{-2}$с$^{-1}$, based on the Nuclotron and new technology of pulsed superconducting magnets with the maximum field up to 6 T.

- Preparation of the project of multipurpose detector MPD (Mixed Phase Detector) for investigation of relativistic heavy ion collisions. Analysis of the setup conceptual schemes, modeling of the collision processes in the energy range of $\sqrt{S_{NN}} = 4 \div 9$ GeV.

- Experiments at the Nuclotron beams on the first priority tasks of the accelerator development, physics and methodical experiments within the total running time of 1200 hours.

List of Activities

	Activity or Experiment	Leader	Status
1.	Nuclotron: development of the accelerator ring systems, injector system, beam lines and bent crystal optics; technology of SC magnets; polarization technologies.	A.D. Kovalenko V.I. Volkov	Realization
2.	Theoretical investigations, development of the models for description of the properties of excited nuclear media under high temperatures and compression, dynamics of nuclear interactions at extreme dense baryon	A.N. Sissakian A.S. Sorin	Realization
3.	R&D work, preparation of the NICA project and the accelerator facility elements.	A.D. Kovalenko I.N. Meshkov	Technical Proposal
4.	Modeling of the processes, R&D work, preparation of the MPD project and the detector elements.	S.V. Afanasiev V.A. Nikitin	Technical Proposal
5.	Obtaining of the experimental data at the Nuclotron nuclear and polarized deuteron beams, important for the MPD design and construction.	A.I. Malakhov	Realization

Key experiments to understand the fundamental nature of matter

Развитие ускорительного комплекса по физике тяжелых ионов высоких энергий (Нуклотрон + НИКА)

“Project NICA”

NICA - Nuclotron-based Ion Collider fAcility and MultiPurpose Detector (NICA / MPD)

представлено В.Д. Кекелидзе

Committee of Plenipotentiaries, March 22- 23, 2007

JINR 1956-2006 DUBNA

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Status of the NICA/MPD project and first-priority tasks for 2007

A.N.Sissakian, A.S.Sorin, V.D.Kekelidze

Programme Advisory Committee for Particle Physics
27 meeting, June 28-29 2007

Status of the NICA / MPD project

V.Kekelidze, A.Sorin
for **NICA** Collaboration

- *Introduction*
- *Physics motivation*
- *New Basic facility*

  *- **Collider NICA***
  ***- Nuclotron-M –** as the first stage*
  - major milestones
- *Experimental tasks*
- *Conceptual design*

  *of the experimental Set-Up – **MPD***
- *Organizational aspects*
- *Summary*

102 session of the Scientific Council, JINR, Dubna, September 27 - 28, 2007

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

ПРИКАЗ

25.04.2007 № 272

г. Дубна

О координации работ по Проекту
NICA/MPD

В соответствии с рекомендациями 101 Сессии Ученого Совета ОИЯИ, одобренными на заседании КПП в марте 2007 года, для координации работ по Проекту NICA/MPD в рамках темы 02-0-1065-2007/2009

ПРИКАЗЫВАЮ:

1. Создать **Координационный Комитет** в составе:
   Сисакян А.Н. - председатель;
   Сорин А.С. - зам. председателя;
   Кекелидзе В.Д. - зам. председателя;
   члены комитета с правом решающего голоса:
   Агапов Н.Н.,
   Зиновьев Г.М. (по согласованию),
   Коваленко А.Д.,
   Мешков И.Н.,
   Потребеников Ю.К.,
   Холлман Т. (по согласованию);
   члены комитета с правом совещательного голоса:
   Афанасьев С.В.,
   Малахов А.И.,
   Никитин В.А.,
   Тонеев В.Д.
2. Утвердить организационную структуру Проекта (Приложение 1).
3. Создать на базе ВБЛВЭ, с привлечением сотрудников других лабораторий ОИЯИ и сторонних организаций, с прямым подчинением директору ОИЯИ, «**Центр NICA-MPD**» для разработки физической программы Проекта, проектов ускорительного комплекса NICA, детектора MPD и создания международной коллаборации для выполнения Проекта.
4. Утвердить временное Положение и временное Штатное расписание Центра NICA-MPD (Приложения 2,3);
5. Сорину А.С., Кекелидзе В.Д. до 20 мая разработать перечень первоочередных задач на 2007 г;
6. Руководство Центром NICA-MPD возложить на зам. директора ЛТФ Сорина А.С.;
7. Обязанности членов координационного комитета распределить следующим образом:

Коваленко А.Д., Мешков И.Н.	-	соруководители работ по разработке и созданию ускорительного комплекса NICA;
Кекелидзе В.Д.	-	координатор работ по разработке и созданию детектора MPD;
Тонеев В.Д., Сорин А.С.	-	координаторы работ по физике;
Потребеников Ю.К	-	координатор работ по созданию компьютерной инфраструктуры Проекта;

Агапов Н.Н.	- координатор работ по созданию производственной инфраструктуры для реализации Проекта;
Зиновьев Г.М., Холлман Т.	- координаторы работ по организации международной коллаборации для реализации Проекта.

8. Обеспечение работ по проекту NICA и согласование вопросов межлабораторного взаимодействия поручить директору ВБЛВЭ Кекелидзе В.Д.

9. Контроль за исполнением настоящего приказа оставляю за собой.

Директор А.Н. Сисакян

к пр-н-272
25.04.2007

Приложение 1

Организационная структура

First-Priority Tasks for 2007 on Preparation of the NICA/MPD Project (Theme 02-0-1065-2007/2009)

	Tasks	Responsible persons	Time of fulfilment
1.	Formation of the organizational structure of the NICA/MPD project	V.Kekelidze A.Sorin	April 2007
2.	Establishment of the NICA Center for implementation and coordination of the NICA/MPD tasks	V.Kekelidze A.Sorin	April 2007
3.	Elaboration of the NICA accelerator complex conception and creation of the relevant physical and draft projects	A.Kovalenko I.Meshkov	April – November 2007
4.	Elaboration of the conception of development of the engineering infrastructure for the NICA accelerator complex	N.Agapov	May – November 2007
5.	Organization of the work on software of modeling and formation of the data basis needed (including creation of the interactive shell NICA/MPD-Root (JINR) on the basis of the MPD drafts for simulation and analysis of modeled events)	O.Rogachevsky	May – August 2007
6.	Elaboration of the MPD conception and preparation of the relevant drafts for simulation of the facility in the NICA/MPD-Root. Formulation of requirements to beams	V.Kekelidze S.Afanasiev V.Nikitin A.Malakhov	April – November 2007
7.	Elaboration of programs for reconstruction of events from the main track detector of the MPD experiment	O.Rogachevsky	Sept. – December 2007
8.	Working out the conception of development of the LHE-LPP computer cluster for the NICA/MPD Project	Yu.Potrebennikov B.Shchinov	May – November 2007
9.	Formulation of the status of the problem (theoretical arguments and experimental indications of possible effects of a mixed phase) for Letter of Intent	V.Toneev	April – November 2007
10.	Organization of a workshop on forming a collaboration and preparing Letter of Intent	V.Kekelidze A.Sorin G.Zinoviev T.Hallman	Sept. – December 2007

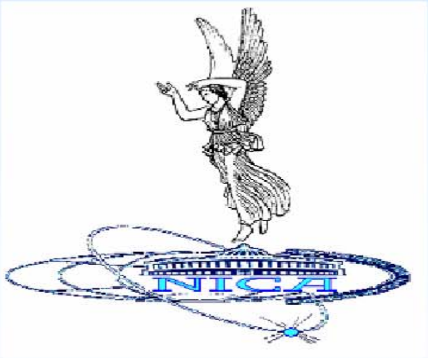
Key experiments to understand the fundamental nature of matter

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Search for the Mixed Phase of Strongly Interacting Matter

at

Nuclotron-based Ion Collider Facility



Dubna, 2007

Nuclotron facility development

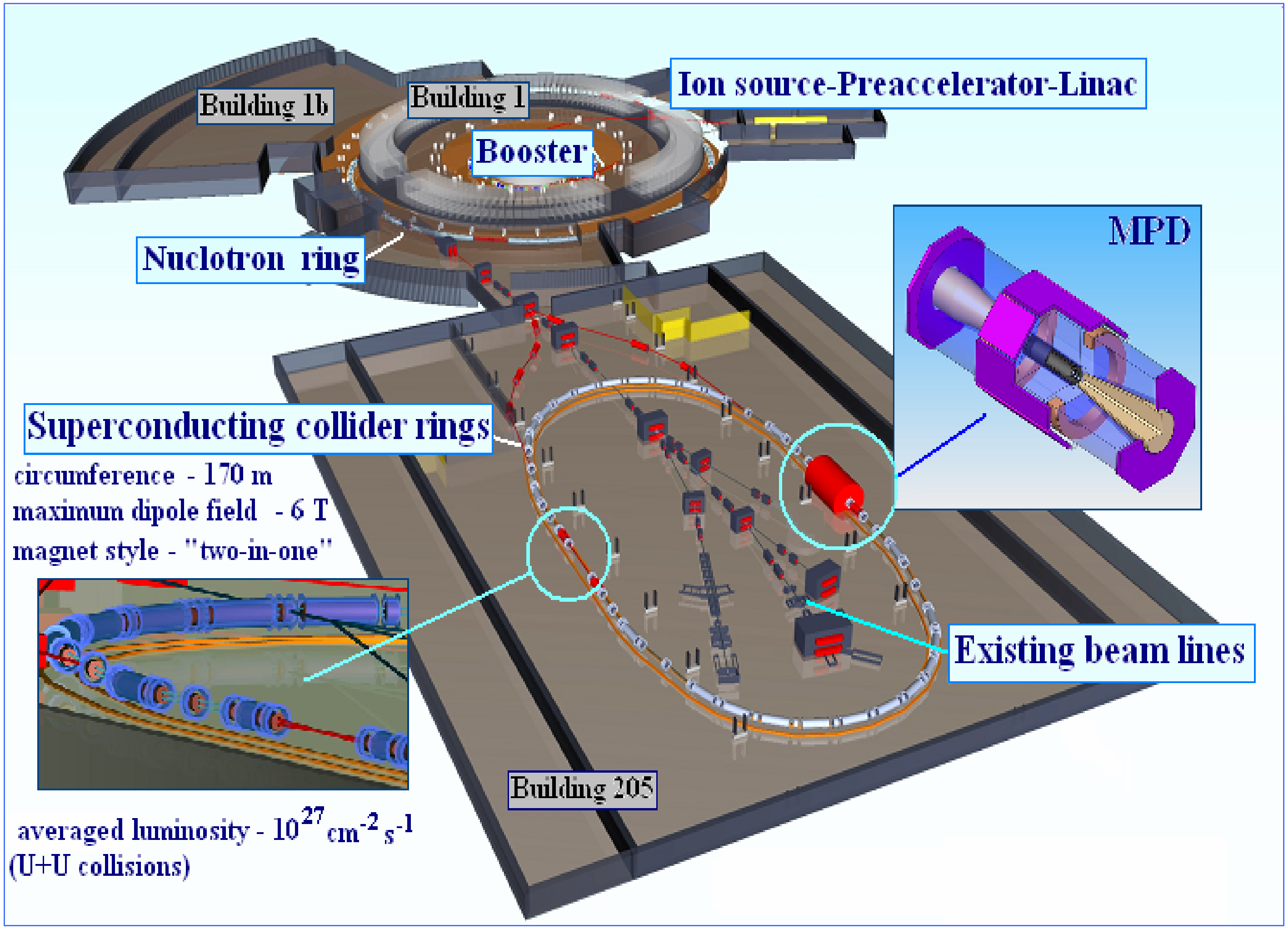
- The Nuclotron, 6 A·GeV synchrotron based on unique fast-cycling superferric magnets, was designed and constructed at JINR for five years (1987-1992) and put into operation in March 1993. The annual running time of 2000 hours is provided during the last years.
- The Nuclotron cryo-magnetic ring of 251.5 m in perimeter is installed in the tunnel around the Synchrophasotron base. The necessary infrastructure for the magnet cooling to 4.5 K exists.
- Ion beams up to krypton and polarized deuterons have been accelerated and extracted from the accelerator.
- Unique technology of highly charged state ion sources (KRION-type) based on ionization by electron impact is developed. The ions up to Au have been obtained at the test bench.
- Fast-ramped superconducting magnet technology is at the highest world level.

Necessary development of the Nuclotron facility includes the following:

- The KRION ion source development
- Improvement of the Nuclotron vacuum system
- Construction of the new pre-accelerator and booster synchrotron
- Electron cooling system
- Partial modernization of beam extraction line and radiation shield
- Development of cryogenic supply and other accelerator and beam control and monitoring systems.

NICA/MPD project

Nuclotron-based Ion Collider fAcility and MultiPurpose Detector



Intense beams from protons to Uranium with maximal colliding energy $\sqrt{s}$=9 GeV (E_{lab}~40 AGeV) and $L=10^{27}cm^{-2}s^{-1}$

Full performance will be reached in 2013

Cost saving factors:
- No new buildings, no additional power lines.
- No extra heat, water cooling power.

The Project NICA/MPD at JINR: Search for the Mixed Phase of Strongly Interacting Matter at Nuclotron-based Ion Collider fAcility

A.N.Sissakian for the NICA collaboration

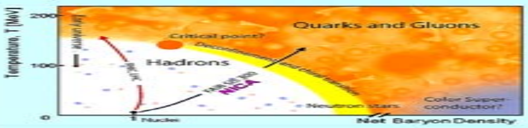
The Joint Institute for Nuclear Research (JINR) in Dubna is an international research organization established in accordance with the intergovernmental agreement of 11 countries in 1956. At the present time, eighteen countries are the JINR Member States and five countries having an Observer status. The JINR basic facility for high-energy physics research is represented by the 6 AGeV Nuclotron which has replaced the old weak focusing 10 GeV proton accelerator Synchrophasotron. The first relativistic nuclear beams with an energy of 4.2 AGeV were obtained at the Synchrophasotron in 1971. Since that time the study of relativistic heavy ion physics problems has been one of the main directions of the JINR research program. The new flagship of the Joint Institute for Nuclear Research is the NICA/MPD project. The main goal of the project is to start in the coming years experimental study of hot and dense strongly interacting QCD matter at the new JINR facility. This goal is proposed to be reached by: 1) development of the existing Nuclotron accelerator facility as a basis for generation of intense beams over atomic mass range from protons to uranium and light polarized ions; 2) design and construction of heavy ion collider (NICA) with maximum collision energy of $\sqrt{s_{NN}}$ = 9 GeV and averaged luminosity 10^{27} cm^{-2}s^{-1} and 3) design and construction of multipurpose particle detector (MPD) at intersecting beams. Realization of the project will lead to unique conditions for the world community research activity. The NICA energy region is of major interest because the highest nuclear (baryonic) density under laboratory conditions can be reached there. Generation of intense polarized light nuclear beams aimed at investigation of polarization phenomena at the Nuclotron is foreseen.

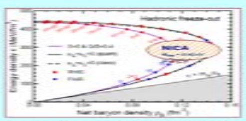
NICA/MPD Goals and Physics Problems

The investigations are relevant to understanding of the evolution of the Early Universe after Big Bang, formation of neutron stars, and the physics of heavy ion collisions. The new JINR facility will make it possible to study in-medium properties of hadrons and nuclear matter equation of state, including a search for possible signatures of deconfinement and/or chiral symmetry restoration phase transitions and QCD critical endpoint in the region of $\sqrt{s_{NN}}$ = 3 – 9 GeV by means of careful scanning in beam energy and centrality of excitation functions. The first stage measurements includes:

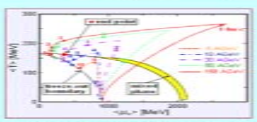
- Multiplicity and global characteristics of identified hadrons including multi-strange particles;
- Fluctuations in multiplicity and transverse momenta;
- Directed and elliptic flows for various hadrons;
- HBT and particle correlations.

Electromagnetic probes (photons and dileptons) are supposed to be added at the second stage of the project. The beam energy of the NICA is very much lower than the region of the RHIC and the LHC but it sits right on top of the region where the baryon density at the freeze-out is expected to be the highest. In this energy range the system occupies a maximal space-time volume in the mixed quark-hadron phase (the phase of coexistence of hadron and quark-gluon matter similar to the water-vapor coexistence-phase). The net baryon density at LHC energies is predicted to be lower. The energy region of NICA will allow analyzing the highest baryonic density under laboratory conditions (see the diagrams presented below). The conditions similar to NICA are expected to be reproduced at FAIR facility in Darmstadt after put the synchrotron SIS300 into operation (in 2015).





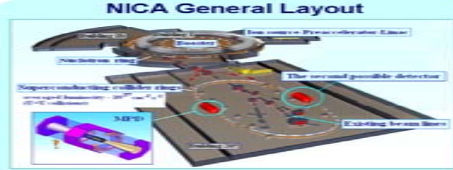
Freeze-out (cease of particle interactions in the system) estimated for different colliding energies (J.Randrup and J.Cleymans, 2006). Freeze-out baryon density is maximal at collider energy $\sqrt{s_{NN}}$ = (4–6) GeV. The blue colored numbers stand for energy in the laboratory system, the red ones – in the c.m. system.



Phase trajectories in the phase diagram calculated within the 3-fluid hydrodynamic model for central Au+Au collisions at different energies (Yu. Ivanov V.Russkikh, V.Toneev, 2005; A.N.Sissakian,A.S.Sorin, M.K.Suleymanov, V.D.Toneev, G.M.Zinovjev., 2005, 2006). Freeze-out curve is shown by dots, the shaded region is a mixed phase for baryon and strange conserved charges. For E_{lab} = 30 AGeV ($\sqrt{s_{NN}}$ = 8 GeV) the trajectory goes near the critical end-point.

Points with numbers indicate the time of the system evolution

NICA General Layout



Construction of the new facility is based on the existing buildings and infrastructure of the synchrophasotron/Nuclotron of the JINR Veksler-Baldin Laboratory of High Energies. The accelerator chain includes: heavy ion source – RFQ injector – linac – booster ring – Nuclotron – Superconducting collider rings. The peak design kinetic energy of U^{92+} ions in the collider is 3.5 AGeV. Beam cooling and bunching systems are foreseen. The collider magnetic system is fitted to the existing building. The project design presumes the use some of fixed target experiments. Polarized deuteron beam from the Nuclotron will be available also. The collision mode is under discussion. The NICA concept was first presented and discussed at the Round Table discussion in October 2006

(see: http://theor.jinr.ru/meetings/2006/roundtable/)

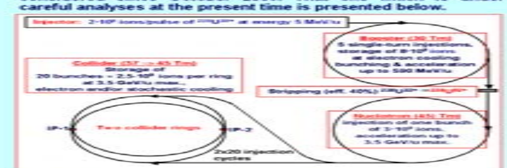
The Nuclotron Upgrade

The Nuclotron, 6 A·GeV synchrotron based on unique fast-cycling superferric magnets, was designed and constructed at JINR (1987-1992) and commissioned in March 1993. The annual running time of 2000 hours is provided during the last years. Ion beams up to iron and polarized deuterons have been accelerated and extracted from the accelerator. View of Nuclotron ring in the tunnel is shown below.

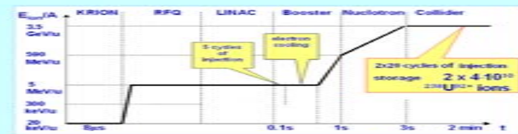
The program of the Nuclotron upgrade in the NICA context is in progress. The ions up to Au have been obtained at test bench based on the unique technology of highly charged state ion sources (KRION-type). Modernization of the Nuclotron is one of the key points in the NICA realization. We are planning the completion of the first turn work by fall of 2009.

NICA Work Scheme

Several schemes of the NICA accelerator complex have been considered since October 2006. That one which is under careful analyses at the present time is presented below.



Operation scenario is illustrated by the diagram. The expected parameters of the collider are presented in the table. The specified average luminosity of $1 \cdot 10^{27}$ cm^{-2}·s^{-1} can be reached at the chosen parameters

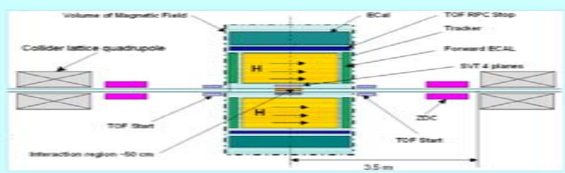


Ring circumference, m	251.2
Ion kinetic energy, E [GeV/u], min/max	1/3.5
Particle number per bunch, $N_{ion/bunch}$	$2.0 \cdot 10^{9}$
Bunch number, n_{bunch}	20
Horizontal emittance, ε [π mm mrad]	0.7
Momentum spread, Δp/p	0.001
IBS life time [sec]	≥ 100
Beta function at interaction points, β*, m	0.5
RF voltage, U_{RF} [kV]	200
Laslett tune shift, ΔQ	0.0044
Beam-beam parameter	0.009
Luminosity, L [cm^{-2}s^{-1}], peak/average	2/ (1÷1.5) · 10^{27}

We consider the possibility to use a space inside the Synchrophasotron magnet yoke window for installation of the booster synchrotron.

MPD for Mixed Phase experiments

The experimental set-up of proposed MPD has to detect the high multiplicity events and perform particle identification. Presented MPD scheme indicates general elements of a typical collider detector which is at the initial stage of conceptual design. The tracking system, both the inner detector based on silicon strips (Silicon Vertex Tracker) and the Tracker provide the reconstruction of primary and secondary vertices and precise measurement of particle momenta. The tracker includes - Central Tracking Detector (CTD) and Forward Tracking Systems (CTS). Two alternative possible options are considered as the CTD: TPC or Straw Tracker (ST). All tracking detectors are situated in the magnetic field of ~0.5 T which is parallel to a beam direction. For the particles identification Time of Flight (TOF) System based on the RPC is proposed. This system allows pion, kaon and proton identification in the momentum region 0.2 - 2 GeV/c. The TPC option of the tracker could provide in addition a particle identification by measuring its ionization energy loss (*dE/dx*). For the electron/positron and gamma detection Electromagnetic Calorimeter (ECal) is considered for the central region and two Forward ECal's for high pseudo-rapidity's. Two options for these calorimeters are under consideration: Crystals or Sandwich of plastic and lead multi layers. Two near the beam sets of scintillator counters are used as start devices for TOF measurements and on-line vertex positioning. The two Zero Degree Calorimeters (ZDC) provide the energy measurement of spectators and determination of "centrality" in the ion-ion collision.



Some basic parameters

- Interaction rate of U+U events at luminosity of 10^{27} cm^{-2}·s^{-1} is 10 kHz. (Interaction rate of central events is of ~ 500 s^{-1});
- The accuracy of vertex reconstraction by means of silicon vertex detector is better then 0.2 mm;
- The TPC produces 30 hits on track and provides momentum measurement accuracy of ~ 1 % in the range of p = 0.2 – 2 GeV/c;
- RPC time of flight system has esolution of ~ 100 ps and provides pion and kaon separation with probability of 5% for p < 2 GeV/c.

Project Milestones

The proposed stages of the NICA/MPD project realization are the following:

Stage 1: years 2007 – 2009
- Development of the Nuclotron facility
- Preparation of Technical Design Report
- Start prototyping of the MPD and NICA elements

Stage 2: years 2008 – 2011
- Design and Construction of NICA and MPD.

Stage 3: years 2010 – 2012
- Assembling

Stage 4: year 2013
- Commissioning

Summary & Outlook

The new facility, of the NICA/MPD, at JINR in Dubna will make it possible to study very important unsolved problems of strongly interacting matter. The design and organization work has been started. The project "Steering Committee" is established. A special scientific department for preparation of the project is formed. The first issue of the NICA/MPD Conceptual Design Report is planned by fall this year. We suppose a wide world cooperation with many Laboratories both at R&D and construction stages of work.

XXIII International Symposium on Lepton and Photon Interactions at High Energy, LP07. August 13-18, Daegu, Korea.

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The Project Milestones

- **Stage 1: years 2007 – 2008**
  - Development of the Nuclotron facility
  - Preparation of Technical Design Report
  - Start prototyping of the MPD and NICA elements

- **Stage 2: years 2008 – 2012**
  - Design and Construction of the Booster Accelerator
  - Design and Construction of NICA and MPD detector

- **Stage 3: years 2010 – 2013**
  - Assembling

- **Stage 4: year 2013**
  - Commissioning

NICA Cost Estimates ($M)

KRION + HV “platform”	0.25
Injector (IHEP design)	10
Booster	8
Collider	2 x 10
Total	~ 40
Infrastructure	~ 12

Required MPD parameters

- $|y|<2$ acceptance and 2π continuous azimuthal coverage
- High tracking efficiency
- Adequate track length for tracking, momentum measurement and particle identification
- Momentum resolution $\Delta p/p<0.02$ for $0.1< p<2$ GeV/c
- Two-track resolution providing a momentum difference resolution of few MeV/c for HBT correlation studies
- Determination of the primary vertex better than 200μm for high momentum resolution to be able to identify particles from the primary interaction
- Determination of secondary vertices for detecting the decay of strange particles such as Λ, K^0_s, $\Xi^{\pm}$, Ω^-
- The fraction of registered vertex pions > 75%

MPD cost estimate ($M) ~ 25

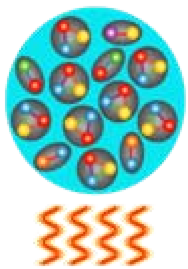
Silicon vertex detector	*4.8*
Time projection chamber	*5.0*
TOF Wall	*4.5*
TOF Barrel	*3.0*
EM calorimeter barrel	*3.5*

Round **Table Discussion III**

Searching for the mixed phase of strongly interacting QCD matter at the NICA/MPD

JINR (Dubna) January, 2008

Résumé



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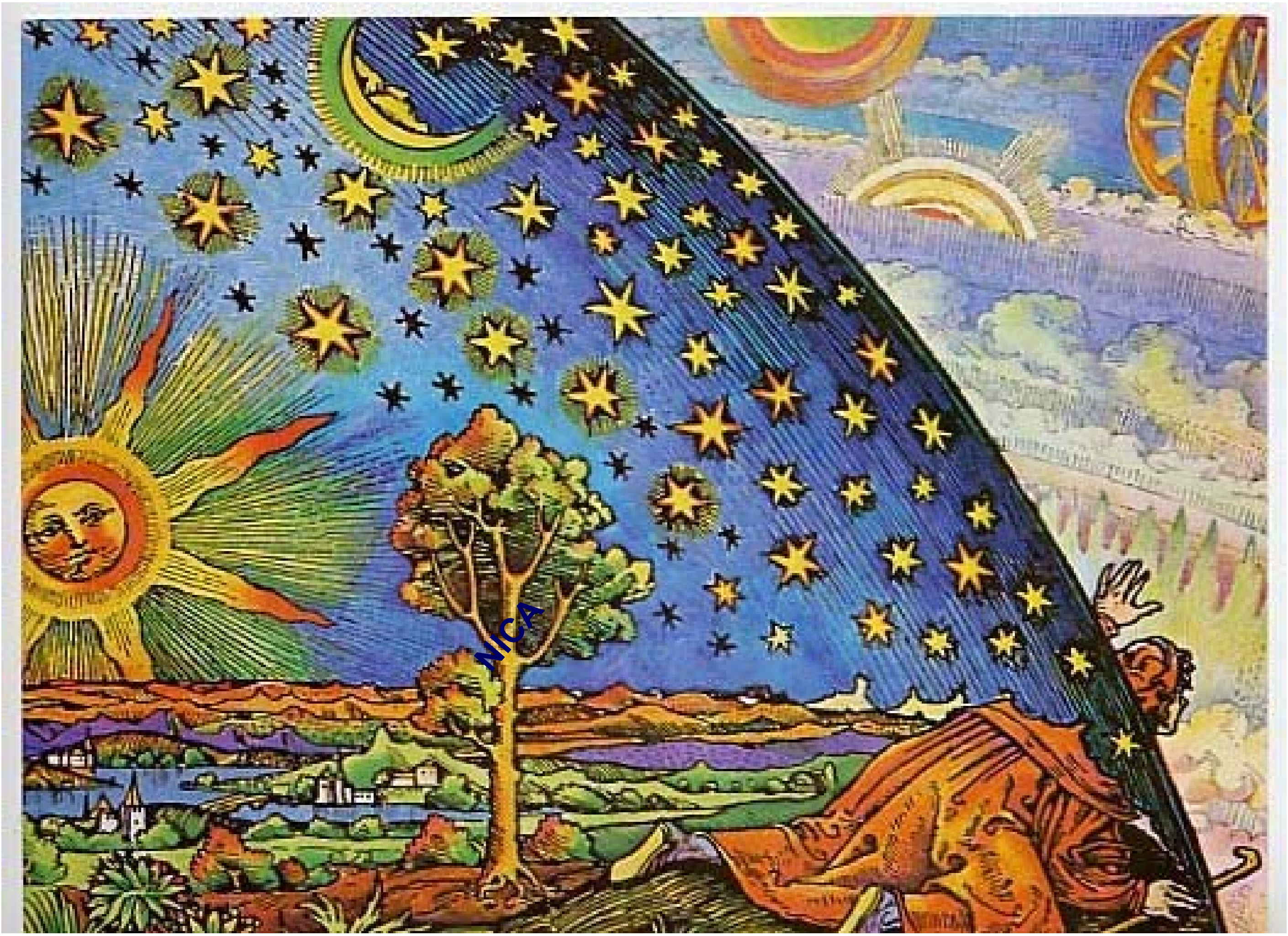

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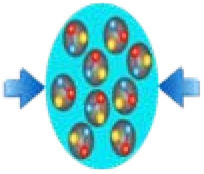

The main work is still ahead!

THANK YOU FOR ATTENTION!